PROCEEDINGS

# SPRAY DEPOSIT ASSESSMENT WORKSHOP

MARCH 16-18, 1976

DAVIS, CALIFORNIA

SPONSORED BY

U.S. FOREST SERVICE, FIDM-METHODS APPLICATION GROUP
USDA EXPANDED DOUGLAS-FIR TUSSOCK MOTH PROGRAM
USDA EXPANDED GYPSY MOTH PROGRAM

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USDA Expanded Gypsy Moth R&D Program

## FOREWORD

This workshop was initiated in recognition of a need to review the state-of-the-art relative to spray deposit assessment methodology.

The overall purpose of the workshop was to bring together representatives of both research and the field to define spray deposit data requirements, review current methodology and state-of-the-art, and identify standard procedures where opportunities exist.

Panels were set up to introduce a subject area and generate discussion by the group. Speakers presented information concerning an assigned subject, reflecting their experiences and viewpoint. Success of the workshop is attributed to the efforts of panel moderators, speakers, and participants through their free exchange of information.

Each panel prepared a summary of their presentations and the group discussion. They also formulated recommendations relevant to their subject matter. These proceedings are a compilation of the panel summaries and recommendations. No attempt has been made to make them a polished document; emphasis was placed on rapidly getting the information to people responsible for field spray activities to assist them in planning for 1976. The information in these proceedings provides preliminary guidelines for evaluating spray deposits achieved during field experiments, pilot and operational control projects. This information will be the basis of a manual on deposit assessment techniques for forest application to be published in the near future. In preparing this manual, comments and additional information is solicited.

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## STATEMENT OF OBJECTIVES

Objectives of the workshop were as follows:

1. Review "State-of-the-Art" for spray deposit assessment under forested conditions, identifying data requirements and optimum techniques for specific uses.
2. Identify standardized procedures for deposit assessment under forested conditions.
3. Have available prior to the 1976 field season preliminary guidelines on spray deposit assessment techniques.
4. Publish a "State-of-the-Art" handbook for spray deposit assessment covering (a) research application, (b) pilot control projects, and (c) operational projects.

SPRAY DEPOSIT ASSESSMENT WORKSHOP

AGENDA

MARCH 16, TUESDAY

| | | |
|---|---|---|
| 8:30 - 8:45 AM | Introduction and Welcome--Goals and Objectives | Ciesla |
| | PANEL I - SPRAY DEPOSIT DATA REQUIREMENTS | |
| | Panel Moderator - K. H. Wright | |
| 8:45 - 9:10 | 1. Research Field Experiments | Markin |
| 9:10 - 9:35 | 2. Pilot Control Projects | Chansler |
| 9:35 -10:00 | 3. Operational Projects | Mounts |
| 10:00 -10:15 | COFFEE BREAK | |
| 10:15 -12:00 | Discussion | |
| 12:00 - 1:00 PM | LUNCH | |
| | PANEL II - SAMPLERS FOR SPRAY DEPOSIT ASSESSMENT | |
| | Panel Moderator - T. McIntyre | |
| 1:00 - 1:20 | 1. Spray Deposit Cards | Yates |
| 1:20 - 1:40 | 2. Plates, Foliage, Insects, and Glass Slides | Neisess |
| | 3. Spray Droplet Assessment on Coniferous Foliage | Barry |
| 1:40 - 2:00 | 4. Rotorods, Millipore Filters and Other Mechanical Devices | Akesson |
| 2:00 - 2:25 | 5. Impaction Efficiencies of Sampling Surfaces | Ekblad |
| 2:25 - 3:00 | Discussion | |
| 3:00 - 3:15 | COFFEE BREAK | |
| | PANEL III - DYES & TRACERS FOR SPRAY DEPOSIT ASSESSMENT | |
| | Panel Moderator - G. P. Markin | |
| | (Materials, availability, capabilities and limitations, physical characteristics) | |
| 3:15 - 3:35 | 1. Oil Base Chemicals | Slack |
| 3:35 - 3:55 | 2. Water Base Chemicals and Microbials | Cowden |

| | | |
|---|---|---|
| 3:55 - 4:15 | 3. Dry Liquids and Dust | Ekblad |
| 4:15 - 5:00 | Discussion | |

MARCH 17, WEDNESDAY

PANEL IV - FIELD PROCEDURES FOR DEPOSIT ASSESSMENT

Panel Moderator - N. Akesson

| | | |
|---|---|---|
| 8:35 - 9:00 | 1. Characterization of Aircraft | Geiser |
| 9:00 - 9:30 | 2. Meteorological Considerations of Deposit Sampling | Armstrong |
| 9:30 -10:15 | 3. Sampler Distributions in Spray Blocks (objectives, designs) | Barry |
| 10:10 -10:30 | COFFEE BREAK | |
| 10:30 -11"00 | 4. Field Handling of Samplers | Ekblad |
| 11:00 -12:00 | Discussion | |
| 12:00 - 1:00 | LUNCH | |

PANEL V - ASSESSMENT METHODS

Panel Moderator - P. Shea

| | | |
|---|---|---|
| 1:00 - 1:30 | 1. Spread Factor Determination | Himel-Waite |
| 1:30 - 2:00 | 2. Field Assessment Methods--D-Max Method of Drop Size Determination | Maksymiuk |
| 2:00 - 2:30 | 3. Laboratory Procedures | Neisess |
| 2:30 - 3:00 | Discussion | |
| 3:00 - 3:15 | COFFEE BREAK | |
| 3:15 - 4:00 | 4. Quantimet 720 for Spray Deposit Card Assessment | Johnson |
| 4:00 - 4:30 | 5. Quantimet Calibration and Standardization Procedures | Partridge |
| 4:30 - 5:00 | Discussion | |

MARCH 18, THURSDAY

| | | |
|---|---|---|
| 8:30 - 9:30 | Summarize Quantimet discussions | |
| | PANEL VI - DATA PROCESSING, ANALYSIS AND REPORTING | |
| | Panel Moderator - R. Young | |
| 9:30 -10:00 | Review of Terminology | Culver |
| 10:00 -10:15 | COFFEE BREAK | |
| 10:15 -10:45 | Data Processing (ADP programs, formats, data processing sources) | Barry |
| 10:45 -11:30 | Methods of Data Processing | Bousefield<br>Young |
| 12:00 - 1:00 | LUNCH | |
| 1:30 - 4:30 | Review, Recommendations and Discussion by Panel Moderators | Ciesla |

# PANEL I

## SPRAY DEPOSIT

## DATA REQUIREMENTS

## PANEL SUMMARY

## SPRAY DEPOSIT DATA REQUIREMENTS

K. H. Wright - Project Manager DFTM Program

Panel Members: K. H. Wright, Moderator
George Markin, Field Experiments
John Chansler, Pilot Control Projects
Jack Mounts, Operational Projects

### I. INTRODUCTION

Assignment - "Spray Deposit Assessment Data Requirements"
--for 3 Kinds of Activities:

- Field Experiments
- Pilot Control Projects
- Operational Projects

Emphasize - Panel charged with identifying "What" kinds of data need to be collected during these 3 activities.

### II. GENERAL PRESENTATIONS

A. Field Experiments (George Markin)

1. Reviewed history of development of spray deposit assessment technology.
2. Emphasized 3 objectives of experimental work in spray deposit assessment:
    a. development of tools for the pest manager
    b. contribute to the insecticide registration process
    c. develop equipment and techniques for carrying out experimentation.
3. Described 5 kinds of studies in which spray deposit assessment is needed:
    a. per cent recovery of spray reaching test area
    b. amount of material reaching the target insect--directly (contact) or indirectly (on food)

c. amount of material reaching non-target organisms directly or indirectly

d. physical properties and fate of the spray cloud leaving the target area (spray drift)

e. studies of spray clouds, to determine their physical properties and performance.

B. Pilot Control Projects (John Chansler)

1. General

a. Pilot projects involve testing the application of promising research findings to operational forest insect management needs.

b. Meaningful pilot projects are the key links between basic/applied research and having the tools to conduct successful operational spray programs. This "cross-over" process must be "smooth, understandable and reasonable."

c. There are no short-cuts in this research and development process. However, some have been taken in the past and "time and time again have given us unpleasant results."

d. Two fundamental rules for determining data requirements for spray deposit assessment in pilot projects.

(1) Sufficient data is gathered to determine whether research results are simulated.

(2) Sufficient data is gathered to determine what will occur under operational conditions.

e. Added a third rule (which overlaps) -- must do adequate assessment to "determine how much and where does the pesticide come down."

C. Data Requirements for Operational Control Projects (Jack Mounts)

1. General

a. Jack said "I can discuss this topic in about 30 seconds because as far as I am concerned no spray deposit data is needed for operational projects."

b. For years, cards were put out to determine whether contractor was meeting contract requirements in regard to coverage.

c. We are now increasingly going to aerial observer monitoring. Thus, spray cards are not necessary to determine "coverage."

d. Correlation between spray deposit and insect mortality is usually very poor. Thus, why do it?

e. There is a correlationship between mortality and spray droplet size, but once the aircraft spray system is calibrated we should not have to continually monitor drop size. The aerial observer and spray operations officer should be able to determine when and if recalibration is necessary.

f. What are the limits in droplet size variation under which we can operate? Will variation of say 5, 10, or 25 microns significantly influence mortality?

g. Expressed concern about never knowing "optimum droplet size."

h. Summary of needs for spray deposit data for operational control projects.

   (1) What is the optimum spray droplet size for each material used?

   (2) How much variation can be tolerated in average size droplet size?

   (3) How much material that isn't deposited on the ground is deposited in tree crowns, as opposed to lost to drift?

   (4) Where and how can we best measure deposit to get accurate determination of <u>effective</u> deposit?

   (5) If we had a better <u>practical</u> method of sampling spray deposit, we might be able to correlate deposit and mortality. If so, determining spray deposit on operational projects might be worthwhile.
   --Under the present state-of-the-art, gathering spray deposit data doesn't buy much."

## III. COMMENTS RECEIVED DURING DISCUSSION PERIOD

- Pilot qualifications are extremely important to good spray deposit.

- Reasons for doing deposit assessment on operational projects:

  -- pay contractor

  -- spot check quality of job

  -- monitor application in non-target, or highly sensitive areas

- Need to broaden measuring of deposit under such conditions as;

  1. normal
  2. off-normal
  3. catastrophic.

- Need meteorologists and spray strategists input on spray applications.

## IV. CONCLUSION

- Our Panel covered the "What" of spray deposit assessment--other panels covered the "how-to-do-it."
- We want to capture and make available to the pest manager "What needs to be done" and "how-to-do-it."

## V. RECOMMENDATIONS

Our recommendations for spray deposit data requirements are presented in the following table.

SPRAY DEPOSIT ASSESSMENT DATA COLLECTION NEEDS

| Activity Requiring Data Collection | Activity and Data to be Collected: Field Experiments | Pilot Control Projects | Operational Control Projects |
|---|---|---|---|
| | Purpose: Develop Specifications | Purpose: Confirm Specifications | Purpose: Maintain Specifications |
| 1. Characterization of Spray Systems<br>a. Aircraft type<br>b. Flight height; air speed<br>c. Boom & nozzle specifications<br>d. Flow rate<br>e. GPA output/time<br>f. Swath widths | Specifications developed from data collected in laboratory, airport and field experiments.<br>--spray volume (g.p.a.)<br>--droplet size (VMD)<br>--swath width (ft.)<br>--droplet density | Data collection restricted to calibration process and follow-up on-site monitoring.<br>--spray volume (g.p.a.)<br>--droplet size (VMD)<br>--swath width (ft.)<br>--droplet density | Data collection restricted to calibration process and follow-up on-site monitoring<br>--spray volume (g.p.a.)<br>--droplet size (VMD)<br>--swath width (ft.)<br>--droplet density |
| 2. Characterization of Formulations<br>a. Active ingredient<br>b. Carrier<br>c. Protectants (e.g., UV screens)<br>d. Adjuvants<br>e. Surfactants | Data, leading to specifications, gathered from manufacturer spec. sheets; and laboratory, airport, and field experiments that tailor the formulation to fit operational needs.<br>Volume to apply (g.p.a.)<br>Droplet characteristics (no., size, break-up)<br>Activity (e.g., bioassay) | Batch samples for spread factor determination.<br>Active ingredient reaching target. | Batch samples for spread factor determination.<br>(No other assessment work needed) |

| Activity Requiring Data | Activity and Data to be Collected | | |
|---|---|---|---|
| | Field Experiments | Pilot Control Projects | Operational Control Projects |
| 3. Spray Recovery in Target Area, e.g.;<br>a. At ground level<br>b. On foliage<br>c. On insects<br>d. Other | Collect data to determine efficacy/deposit relationships, and to develop specifications for field sampling surfaces to be used in determining deposit volumes, e.g.:<br>Volume (g.p.a.) recovery<br>Drop spectrum & no.<br>VMD or MMD<br>Active ingredient | Collect sufficient data to ensure specifications are met for the variables being tested.<br>Percent recovery<br>Drop spectrum | Collect only sufficient data to ensure that prescribed volume and form of insecticide has reached insects. |
| 4. Spray Recovery on Non-Target Areas | Develop standard equipment and technology that are adequately sensitive for measuring deposits. Determine if levels of AI effective on target have adverse effects on other resources.<br>Examples of data:<br>Volume reaching non-targets<br>Drop spectrum | Sample adequately to ensure that deposits on sensitive non-target areas are known and can be evaluated.<br>Volume reaching non targets | Sample adequately to ensure that deposits on sensitive non-target areas are known, minimized and can be evaluated.<br>Volume reaching non-targets |
| 5. Meteorological Measurements | Determine equipment and technology for determining effects of meteorological variables on performance of insecticide formulation being tested.<br>(Kinds of deposit assessment depends on objectives of specific studies.) | Use specified equipment and technology on adequate sample basis to monitor spray cloud, and evaluate results of project.<br>(Kind and amount of data collected depends on need.) | Use specified equipment and technology on adequate sample basis to monitor spray cloud, and evaluate results of project.<br>(Data collection depends on need.)<br>Determine why cloud behaves as it does. |

| Activity Requiring Data | Activity and Data to be Collected | | |
|---|---|---|---|
| | Field Experiments | Pilot Control Projects | Operational Control Projects |
| 6. Spray Cloud Form and Drift | Collect data needed to determine physical properties and fate of the spray cloud formed in, deposited on, and leaving the target area.<br><br>Data collected depends on specific objectives of experiments. | Use standardized procedures and materials to monitor and evaluate spray cloud performance and drift, particularly into sensitive areas.<br><br>Usually no data collection needed. | Use standard procedures to monitor drift into sensitive areas if present.<br><br>Volume deposited, and location, in sensitive areas. |

# PANEL II

## SAMPLERS FOR SPRAY DEPOSIT ASSESSMENT

# PANEL SUMMARY

## SAMPLERS FOR SPRAY DEPOSIT ASSESSMENT

Tom McIntyre - Moderator
Program Manager, Gypsy Moth Program

Panel Members: Tom McIntyre, Moderator
Wesley Yates, Spray Deposit Cards
John Neisess, Plates, Foliage, Insects & Slides
Jack Barry, Coniferous Foliage
Norm Akesson, Air Samples (Rotorods, Filters, etc.)
Bob Ekblad, Impaction Efficiencies of Sampling Surfaces

I. SPRAY DEPOSIT CARDS (Wesley Yates)

Use of card technique determines:

Number and size of particles on:

-- target and non-target areas and results in:

1. Drop size spectrum
2. Drop density -- which can be converted to volume, i.e., gal./acre, ppm, etc.

Types: Dyed cards/Oil Spray

1. Oil Red "O" dye
2. Sudan black dye
3. Undyed white cards/dye in spray -- available for water base and oil sprays.

Other Systems:

1. Flourescent tagged sprays, Rhodamine B
2. Black dyes, Nigrosine and Sudan Black
3. Special papers sensitive to spray used, e.g., thermofax copy paper

Limitations of card assessment

1. Small drops do not always impinge thus they may not be assessed accurately

2. For spread factor determination we need to know:

    a. types of sprays
    b. spread for various drop sizes
    c. type of card

3. Card recovery may not be efficient. Personnel problems and high costs. Small particles sheer.

4. Data not always available for recommended card location to obtain representative sample.

## II. FOLIAGE, PLATES, GLASS, SLIDES, INSECTS, ETC. (John Neisess)

Glass and metal plates, cards, foliage and insects have all been used in assessment procedures. Insects and glass slides thus far are utilized less and are far from perfected or "standardized."

For western defoliators (tussock moth and western spruce budworm), foliage samples around tree at mid-crown, at four cardinal points has provided reasonable assessment representation. Correlation with insect mortality data at same sample points is also possible. Correlation of insect mortality and deposit data have not been made for deciduous species.

Some studies show card (dye and other) and metal plate evaluations placed side by side provide reasonably good correlations.

Data which can be obtained by various assessment techniques:

<u>Quantitative</u>

Plates: volume per acre, or oz. AI/acre

Foliage: volume/acre or oz. AI/acre

For hardwoods, deposits are greater in top crown. Volume/gram foliage or mass AI/gram foliage can be determined for conifers

<u>Counting Methods</u>

Glass: drops/unit area and VMD's

Insects: drops/bug

Foliage: deciduous - drops $cm^2$ or percent leaves with drops

conifer - drops/needle or percent needles with drops

## III. OTHER AIR SAMPLING DEVICES (ROTORODS, FILTERS, ETC.) (Norm Akesson)

Several basic air sampling devices used essentially for research have direct applicability to pilot control projects and operational programs. Rotating rods, wires, slides, etc. are secondary collection devices. Speed of rotation, size of particles being collected, and collector surface influence efficiency of impaction.

Of the basic systems in use, cascade impactors are most sensitive for smaller particles--collecting more efficiently the 1 µm to 20 µm material.

More sophisitcated air sampling devices are essential for studies involving aerosol type sprays--or drift away from target area.

Automatic type samplers nearly all require various power sources--battery, generator, etc.

## IV. IMPACTION EFFICIENCIES (Bob Ekblad)

An understanding of terminal velocity of droplet fall in relation to density and drop size is essential to understanding impaction efficiency.

| Example: | Drops-µm | Terminal velocity-mph |
|---|---|---|
| | 40 | 0.1 |
| | 150 | 1.0 |
| | 400 | 3.9 |

"Impaction efficiency" is the ratio of drops impacting on a surface to number approaching. Factors involved are:

1. Shape, size, and position of surface
2. Drop weight, diameter and speed
3. Air speed and direction

Sampling devices:

1. Cylinders -- present uniform collection surfaces regardless of wind direction. Wrap cards around cylinder. Scan card to obtain horizontal segment of sample area to reduce non-uniformity.
2. Spheres -- simple devices such as ping pong balls can provide quick qualitative assessments.

3. <u>Flat Cards</u> -- when vertical they must face into wind. Horizontal cards placed 18 inches above the ground to avoid vegetation give an estimate similar to ground cards for gross deposit and vmd for spray clouds about 200 microns vmd.

## V. SPRAY DEPOSIT ASSESSMENT ON FOLIAGE (Jack Barry)

The ideal sampler is the ultimate target for the spray. For most forest spraying the target is either the tree leaves or an insect exposed on a leaf. Most foliage assessment in the past has dealt primarily with washing and determining total mass. The current emphasis on understanding the target/spray drop size relationship dictates assessing (counting and sizing) droplets directly on the target surfaces.

Foliage assessment can produce either qualitative or quantitative data. One can simply scan a given unit of foliage and count the number of drops on the foliage.

Compared to the deposit card sampler for qualitative information, this technique is probably more meaningful and certainly just as easy to execute in the field.

Requirements of using foliage as an assessment system:

1. Dye used must be visible and stain surface
2. Preferable flourescent types
3. Stability in sun and compatibility with spray are essential.

Advantages:

1. Inexpensive for field crews to collect samples
2. Simple lab equipment (stereo scopes) available to most for analysis.

System provides:

1. Data on spray coverage (qualitative and quantitative)
2. Data on spray drop sizes.

Method: -- Foliage samples may be most effective when coupled with supplementary system, i.e., cards.

## RECOMMENDATIONS

### SAMPLERS FOR SPRAY DEPOSIT ASSESSMENT

1. Use horizontal samplers near ground for spray clouds of medium-large drops in low winds. Medium drops are defined as 100-400 µm. Standard USFS Kromekote cards should be used. Cards should be positioned at the drip line of the designated sample tree at the cardinal directions. The MEDC card holder should be used to keep the card in a rigid position, clean, and for ease of handling.

2. For sprays of fine-medium drops at elevated heights in drift situations, use cylinders.

3. Size (diameter) of cylinders for samples should be standardized.

4. Biological samples provide best deposit data.

5. There are limitations to samplers. These should be understood. There is no one sampler which will provide all data which may be required.

# PANEL III

## DYES & TRACERS

## FOR

## SPRAY DEPOSIT ASSESSMENT

# PANEL SUMMARY

## DYES AND TRACERS FOR SPRAY DEPOSIT ASSESSMENT

George P. Markin - U.S. Forest Service, PSW

Panel Members: George P. Markin, Moderator
Ted Slack, Oil-based sprays
Bob Cowden, Water-based sprays
Bob Ekblad, Dry liquids and dusts

## I. GENERAL RECOMMENDATIONS

Examine each situation ahead of time to fully assess needs for dyes or tracers. In particular, is a dye or tracer needed--many materials such as No. 4 fuel oil or microbial materials are dense enough that they do not need a dye. Similarly, such items as Dylox and Sevin for certain purposes can be assessed against a black background and no dye is needed. The most sensitive way of measuring the amount of insecticide at the target area is the direct use of gas liquid chromotography and not a dye. If highly accurate readings are needed, it is recommended that GLC be used instead of a tracer.

## II. WATER-BASED SPRAYS (Bob Cowden)

### A. Research Needs

1. The most accurate method (other than GLC) for determining volume of spray per unit area, or the amount of material on foliage is by using salt tracers and analysis by atomic absorption (such as manganese sulfate or strontium chloride).

2. For determining number of drops per area, size of drops, etc. by spot counter, Sudan black (Nigrosine) or Rhodamine B can be used. Quantity of dye needed depends upon the type of assessment equipment to be used. Researchers are encouraged to contact persons who will do the assessment to see that there is compatibility between their choice and quantity of dye and the assessment equipment to be used.

3. For determining volume of material or amount of material on foliage by fluorometric means, Rhodamine B water-soluble dye

is recommended. Rhodamine B has the disadvantage, however, in that it undergoes fading at non-constant rates depending upon the exposure to sunlight.

B. Pilot Control Project Needs

Rhodamine B is recommended as the best all around dye for pilot control projects.

C. Operational Project Needs

The tracer to be used should be chosen specifically to fit the deposit assessment needs of the operational program. Many operational programs may need no dye for assessment. Others may need dye only in randomly selected loads as a spot check on treatment. Dyes are recommended from a safety aspect since they improve safety in handling insecticides and facilitate locating spills and dumps.

## III. OIL-BASED SPRAYS (Ted Slack)

A. Research Needs

Salt tracer techniques are not available at this time for oil-based sprays. To determine amount of material recovered, GLC's are recommended as being the most accurate. A secondary method for measuring volume or amount of spray would be the use of Rhodamine B oil-soluble spray, and determining deposit fluorometrically. For analysis with spot counters Automate Red and Rhodamine B are recommended. Amount of dye per gallon of spray depends on the type of spot counter to be used. Researchers should check with the group planning to do the assessment to see that the quantity of dye to be used is compatible with the requirements of the equipment. Generally, the amount of Automate Red needed is from 0.5-2%; Rhodamine B is 0.1%.

B. Pilot Control Project Needs

Both Automate Red and Rhodamine B oil base are recommended for pilot control projects when cards are being analyzed by spot counters for number and size. Rhodamine B can be used fluorometrically and Automate Red can be used colorometrically for determining volume and amount of spray recovered. However, it must be remembered that Rhodamine B undergoes fading in the field.

C. Operational Project Needs

Choice of dyes for operational projects depend entirely upon the type of assessment data to be collected. Some projects may need

no assessment data, therefore no dyes would be required. Other times dyes may be needed only on selected loads as a spot check on the treatment. Rhodamine B and Automate Red are probably the most suitable dyes available at this time for operational use if needed.

## IV. DRY LIQUIDS AND DUSTS

Dry liquids and dusts are useful for highly specialized spray deposit assessment needs of the researcher. No feasible use of dry liquids or fluorescent dusts is seen in either pilot control or operational projects at this time.

## V. GENERAL COMMENTS

Rhodamine B is very widely used by various researchers. The following problems with the material have been encountered:

1. Some researchers feel that Rhodamine B oil-soluble may not be as sensitive when analyzed fluorometrically as Rhodamine B water-soluble.

2. Rhodamine B is available in both a powder form and a liquid solution. The powdered form has a good shelf life, although it is hydroscopic and can change in weight as much as 10% depending on the humidity of the air. The water-soluble formulations were reported to have a limited shelf life since the Rhodamine will crystalize or settle out of solution.

3. Rhodamine B apparently has some type of an inert contaminant in it in the form of small resin-like particles or beads. With normal spray equipment this is not a problem. However, with some specialized spray systems with very fine nozzle orifices or with fine screen filters, the particles may build up and clog the orifices.

4. Rhodamine B water-soluble is usually added directly into the water formulation during mixing of the insecticide, but no problems were mentioned in getting it into solution. Oil-based Rhodamine B, however, has been found to go into solution a little harder. Dr. John Neisess recommends that it first be dissolved in oleic acid at the rate of 38 grams/quart of oleic acid and then mixed with the oil-based formulation at the rate of 1 quart oleic acid dye to 10 gallons of spray formulation (final concentration = 0.1% dye).

5. Rhodamine B dye at present has a 5 ppm tolerance level in human foods, so no immediate problem from EPA is expected in the use of this material.

## VI. COSTS OF DYES

Approximate price per pound and cost of using various dyes at 1 gallon/acre of final spray solution are as follows:

| DYE | COST OF TECHNICAL MATERIAL | CONCENTRATION | | COST PER ACRE |
|---|---|---|---|---|
| Automate Red | $2.00/lb in 40 lb lots | 0.5% | = | $ .08/acre |
| | | 1.0% | = | $ .16/acre |
| | | 2.0% | = | $ .32/acre |
| Rhodamine B (water-soluble) | $7.60/lb in 50 lb lots | 0.1% | = | $ .06/acre |
| | | 0.2% | = | $ .12/acre |
| Rhodamine B (oil-soluble) | $9.00/lb in 50 lb lots | 0.1% | = | $ .07/acre |
| | | 0.2% | = | $ .14/acre |
| Oleic acid | $5.50/gal | 2.5% | = | $ .14/acre |
| Nigrosine dye | $1.80/lb in 20 lb lots | 0.5% | = | $ .07/acre |
| | | 1.0% | = | $ .14/acre |

Prices are approximate and based on 1975 prices

# PANEL IV

## FIELD PROCEDURES FOR DEPOSIT ASSESSMENT

## VI. COSTS OF DYES [1]

Approximate price per pound and cost of using various levels at 1 gallon/acre of final spray solution are as follows:

| DYE | COST OF TECHNICAL MATERIAL | CONCENTRATION | | |
|---|---|---|---|---|
| Automate Red | $2.00/lb in 40 lb lots | 0.5% | = | $ [illegible] |
| | | 2.0% | | $ .32/acre |
| Rhodamine (water-soluble) | $7.60/lb in 50 lb lots | 0.1% | = | $ .06/acre |
| | | 0.2% | = | $ .12/acre |
| Rhodamine B (oil-soluble) | $9.00/lb in [illegible] | 0.1% | | .07/acre |
| | | | | $ .14/acre |
| Oleic acid | $5.50/gal | 2.5% | = | $ .14/acre |
| Nigrosine Dye | $1.80/lb in 20 lb lots | 0.5% | = | $ .07/acre |
| | | 1.0% | = | $ .14/acre |

[1] Prices are approximate and based on 1975 prices.

## PANEL SUMMARY

## FIELD PROCEDURES FOR DEPOSIT ASSESSMENT

N. B. Akesson - Agricultural Engineering Dept., U. C. Davis

Panel Members: Norm Akesson, Moderator
Archie Geiser, Aircraft Characterization
Jack Armstrong, Meteorological Considerations
Jack Barry, Sampler Distribution
Bob Ekblad, Field Handling of Samplers

### I. CHARACTERIZATION OF AIRCRAFT (Archie Geiser)

The primary calibration means used by Plant Protection and Quarantine (PPQ) for aircraft applications is by:

1. Determining acres covered in a specified swath over a specified distance such as one mile.
2. A given quantity of liquid discharge is found, such as a measure of the quantity for refilling of the spray tank after the given pass. Combining these produces a gallon per acre number. The gallon per minute flow rates can be found in a time for discharging a given volume.

   Specific nozzle type, number, placement on the boom, pressure and other factors controlling drop size, flow rate, and swath width are performed with PPQ aircraft. This information is passed on to the contractors for use on their aircraft. Field checking of all contract work is done by PPQ field men.

### II. METEOROLOGICAL CONSIDERATIONS ON DEPOSIT SAMPLING (J. A. Armstrong)

Minimum weather measurements suggested are wind speed, direction and temperature differential. These parameters are taken at specified height intervals (one set above the tree canopy). Certain correlation functions such as stability ratio and other turbulence numbers can be used and related to deposit and insect control.

These have shown correlation at various levels and indicate that meteorological parameters may have significant importance on the effectiveness of aerial application, perhaps equal to such other physical factors as spray volume, drop size and spray drop density.

Instrumentation for experimental studies can become very sophisticated, but relatively simple techniques, such as burning tires for a heavy smoke, can be used along with inexpensive temperature and wind velocity instruments for pilot control and operational projects. Meteorological information should be available for every large scale field project as an aid in determining and following most appropriate application weather.

## III. SAMPLER DISTRIBUTION IN SPRAY BLOCKS (John W. Barry)

Data requirements may be defined as qualitative and quantitative. Under the first may be tested:

1. spray coverage over a spray area
2. drift (airborne) to non-target areas, streams, roads, buildings, and general environment
3. coverage of sample trees

and under the second:

1. recovery or accountancy on a percent basis of total material released
2. canopy penetration and deposit comparisons
3. recovery (deposit) and correlation to insect mortality
4. spray characteristics; drops, mass and various statistical descriptions of the release.

Deposition cards are relatively simple, inexpensive and functional for monitoring forest spray programs for all three types of projects; experimental, pilot and operational applications. Spray deposit cards have a background of 25 years use which gives a base for judgment--still a valuable item for any project. Both gravimetric and volumetric data on deposit and recovery can be obtained, but evaluating volume recovery is subject to significant error due to evaporation and extreme sensitivity when expanded from a stain size to a volume applied. Errors in the gravimetric evaluation basically relate to sensitivity of the chemical analysis (colorometric is generally inadequate) and degradation of the chemical after application but before stripping and analysis.

Size-frequency data from cards is best obtained by use of the Quantimet automatic sizing instrument, but microscopic evaluation by eye can also

be used for the drop information and volumetric evaluation. G-L chromatographic instruments as well as atomic absorption devices are also used for gravimetric evaluation of the deposits.

Correlation of either mass or volume deposits on plant leaf or needle surfaces with cards placed in trees has not been very satisfactory. It would appear that a broader statistical base is required or evaluation of much more data, for adequate correlation and comparison of deposits (volumetric) on leaf surfaces and artificial collection surfaces, and the further step to insect control. Gravimetric data (micrograms per unit area or ppm) appears to have had more success in reproducibility and accuracy, such as on comparison of collection between leaf and artificial surface deposit.

## IV. FIELD HANDLING OF SAMPLERS (Robert Ekblad)

The use of deposit cards in the field poses many problems, not all technical. The organization of people to properly, carefully and accurately handle, place and pick up cards will govern the value of the data so collected. These people should be told more than the elemental details of the project. By giving them a full view of what is being done greater reliability of data collection can be achieved.

Radio communication and other logistical factors are very important. Orientation of the handling crew for proper identification of cards as to placement in and around trees must be simple and positive. Use of magnetic compasses, for example, is better oriented to magnetic direction rather than expecting handlers to make proper declination or other correction.

Decisions for number and position of cards and where they will be placed in the tree must be made in advance, as well as instructions for caring for cards, such as removing insect and plant detritus and protection of cards from dew and rain. These instructions need to be transmitted to the handling crew both orally and in simple written instructions.

The value of field data collected on a routine basis is only as good as the effectiveness of the field handlers. The early morning hours, the eventual boredom of the repeated operations and the human inclination to take the path of least resistance all must be considered along with the data value when monitoring programs at the field application level are considered. Experimental and pilot programs must, of course, utilize all possible techniques for field data evaluation.

... the [illegible] information ...
... and [illegible] instruments as ... [illegible] ...
... would [illegible] for gravimetric evaluation of the deposit ...
... variety.

... [illegible] of either mass or volume deposits on plant ... surface ... cards placed in trees has not ... factory. It would appear that a broader statistical ... or evaluation of much more data, for adequate ... of deposits (volumetric) on leaf surfaces ... or collector surfaces, and the further step ... [illegible] ... metric data (as micrograms per unit area) ... in reproducibility and ... between leaf and artificial surface.

FIELD HANDLING OF SAMPLERS (R... [illegible])

The use of deposit cards in the field ... technical. The organization of people to properly ... accurately handle, place and pick up cards will ... the data collected. These people should be ... essential details of the project ... what is being done greater reliability of data ... achieved.

Radio communication and other logistical ... implementation of the handling crew ... placement in and around trees must ... of magnetic compasses, for example, ... direction rather than ... or other correction.

... [illegible] ...

Provisions for number and position of cards ... in the tree must be made in advance, as well as ... caring for cards, such as removing insect and plant ... detection of ... dew and ... transmitted to the handling crew ... instructions.

The value ... collected on a ... basis ... as the direction ... the field handling ... the eventual ... the assigned operations ... to take the ... of least ... must be ... with data value when ... level ... [illegible] ...

# PANEL V

# ASSESSMENT METHODS

## PANEL SUMMARY

## ASSESSMENT METHODS

P. Shea - U. S. Forest Service, PSW

Panel Members: Pat Shea, Moderator
Chet Himel, Spread Factor Determination
Richard Waite, Spread Factor Determination
Bohdan Maksymiuk, D-Max Method of Drop Size Determination
John Neisess, Laboratory Procedures
Kaye Johnson, Quantimet 720 for Spray Card Assessment
Bryon Partridge, Quantimet Calibration and Standardization

### I. SPREAD FACTOR DETERMINATION (Himel-Waite)

Standard methodology is available to determine spread factor for any available formulation. In order for the user to effectively use the Kromekote cards or any field sampler, spread factors must be determined for each formulation and the various size classes within the formulation. The determination of a particular spread factor involves the production and collection of streams of uniform-sized droplets from which a calibration curve can be made. Since most sampling surfaces record drops as stain (dyed) marks, the conversion factor must be determined to determine the actual drop size.

New methodology is being developed to more efficiently and accurately determine spread factors for small droplets. Although still experimental, this new methodology can provide a means of characterizing and evaluating new nozzle devices.

### II. D-MAX METHOD OF DROP SIZE DETERMINATION (Maksymiuk)

Using the D-max method one can rapidly and accurately determine the vmd of most oil-based sprays. Limitations of the method are that it may not be applicable to oil-based sprays in the smaller droplet spectrum. It is undetermined at this time whether the methodology is usable for water-based sprays.

## III. LABORATORY PROCEDURES (Neisess)

Physical, analytical, and biological methods are available for laboratory assessment of spray deposit. Counting dyed (colored or fluorescent) droplets on cards, needles, leaves, etc. are typical physical methods of determining deposit. Washing quantities of dyed or undyed sprays from inert surfaces can be done to analytically determine actual ingredients. Biological assessments include counting Bacillus spores on known surfaces or feeding contiminated food to susceptible insects and recording mortality.

## IV. QUANTIMET 720 FOR SPRAY CARD DEPOSIT ASSESSMENT (Johnson)

Suggestion for consideration:

1. limit size spectrum classes to 16 or less
2. use as much dye (concentration) as possible
3. minimize computer programming by standardization of data reduction requirement
4. clean and careful handling of spray deposit cards
5. preplan numbering system to meet computer sorting requirement
6. small scale round robin on samples of the various cards and dyes to get users "homing" in on data base
    a. Objective: To compare results of the four instruments in counting spots on cards. A completion day of May 1, 1976.
    b. Instruments:
        (1) Los Alamos
        (2) USFS Corvallis
        (3) U. C. Davis
        (4) Cambridge Instrument, Mt. View, CA
    c. Design: Start with "few" known spots. All instruments will look at same spots
    d. Participants:

| | |
|---|---|
| Bryon Partridge | - Coordinator |
| Kaye Johnson | - Assist Partridge in design |
| Richard Waite | - Provide samples |
| Jack Barry | - USFS liaison; work directoy with Partridge |

## V. CALIBRATION AND STANDARDIZATION OF 720 QUANTIMET (Partridge)

Some sources of error applicable to spray deposit measurements are related to:

1. finite resolution
2. shading and threshold errors
3. noise
4. logic errors
    a. edge errors
    b. counting errors

Things to consider to reduce inaccuracies are:

1. Limitation of measurement of feature accuracy. Accuracy limits should be defined. Trade-offs; accuracy versus speed.
2. Sources of shading: illumination, optics and scanner. Shading correction and automatic detectors. Video filtering and limitations.
3. Low contrast features and small features. Use of Plumbicon scanner versus Vidicon scanner. Fluorescent droplets. Light integration. Use of data averaging.
    a. Use of "guard region"
    b. Agglomeration of droplets on cards. Use of image editing facility.

Calibration of the system is, in itself, very simply achieved using an electronic graticule or standard frame of known size.

# PANEL VI

## DATA PROCESSING, ANALYSIS AND REPORTING

# PANEL SUMMARY

## DATA PROCESSING, ANALYSIS AND REPORTING

Robert W. Young - U. S. Forest Service, MAG-FIDM

Panel Members: Robert W. Young, Moderator
Andrew J. Culver, Standardization of Terminology
John W. Barry, Data Processing
Wayne Bousfield, Statistical Analysis

## I. STANDARDIZATION OF TERMINOLOGY (Culver)

Standardization of terminology is extremely important within and between industry and government agencies to insure comparability, understanding, and interpreting information. An organization, American Society for Testing and Materials (ASTM) has been formed for the development of standards on characteristics and performance of materials, products, systems and services, and the promotion of related knowledge.

Examples of the types of standards are:

1. Standard definitions which create a common language for a given area of knowledge.
2. Standard recommended practices which suggest accepted procedures for performing a given task.
3. Standard methods of testing which prescribe ways of making a given measurement.
4. Standard classifications which set up categories in which objects or concepts may be grouped.
5. Standard specifications which define boundaries or limits on the characteristics of a material, product, system, or service.

ASTM is a management system for the development of voluntary full consensus standards. It provides a legal, administrative, and publications forum within which producers, consumers and those representing the general interest can meet on a common ground to write standards, which will best meet the needs of all concerned.

People concerned with the standardization of processes can have inputs to ASTM by going to their meetings or by writing to specific committees. A more effective way to express ideas would be to join ASTM and actively work on specific committees. Committee E-35 deals with pesticides.

RECOMMENDATIONS:

1. Canvas FIDM, MEDC and other relevant groups to determine membership status to ASTM and to what committees assigned.
2. Determine key individuals from above units to become members of ASTM to work on appropriate committees.
3. Begin to implement the metric system in sampling plans and reports.

## II. SPRAY DEPOSIT ASSESSMENT COMPUTER PROGRAM (Barry)

A system has been developed to summarize data from spray cards. The major components of the system (overall sequence of events) are listed below:

1. Determine spray formulation, specific gravity and spread factor from each project.
2. Collect spray deposit cards from field.
3. Identify cards with appropriate sample design-block, cluster, tree, location, open area, under trees, etc.
4. Submit spray cards to appropriate lab to be processed by the Quantimet.
5. Determine parameters needed for the Quantimet (drop size intervals and area of spray card to be counted).
6. Process spray cards by the Quantimet.
7. Obtain output data from Quantimet (usually punched data processing cards and a listing of an analysis of each spray deposit card).
8. Process the data processing cards through the spray deposit assessment computer program.
9. Extract data from printout, analyze, and integrate data into the field experiment, pilot project, or control project reports.

The entire process from field collection to ADP printout can be accomplished in about 4 weeks. It is imperative that the project leader be aware of the sequence of operations and monitor each step closely.

Specific comments about the spray deposit assessment computer program follow:

Basically, the program reads punched cards containing card identification and number of stains in the various size categories specified, 16 at the present time. Through spread factor equations and specific gravity input for the subject formulation, the stain diameters are converted to drops (spheres) and various output values are then computed, including mass mean diameter (MMD), volume median diameter (VMD), number mean and number median diameters, number of stains per unit area and amount of mass per area. These values are computed and printed for each spray deposit card and summarized at higher levels, i.e. spray blocks.

One of the most annoying problems with the data is to get it in a form so that the summarized data is meaningful. The computer program sorts the data on the identification from each spray card. The spray deposit cards must have proper identification as specified by the project officer.

It also must be emphasized that the programer and user be alert to errors which may develop due to programing, punch cards, punching errors, etc.

This program is very useful to both the researcher and to those conducting pilot and operational projects. It provides a rapid method of determining spray deposit and understanding spray behavior over the spray area. When used in conjunction with insect mortality and meteorological data, it provides a basis of understanding spray behavior and designing future experiments and control projects.

RECOMMENDATIONS:

1. Short range: Implement the spray assessment system on the U. C. Davis and Fort Collins computers so that FIDM-MAG can assist the field in getting the jobs processed in-house for the 1976 season.
2. Long range: The spray deposit assessment computer programs be fully documented so that users in the Forest Service Regions/Areas can run the programs themselves using the F.C.C.C.
3. Output from the system should be explained in detail so users can easily interpret results.
4. Users' needs should be developed and used for inputs for program modifications. MAG will initiate program changes and keep documentation of the system current.

## III. STATISTICAL ANALYSIS OF SPRAY DEPOSIT DATA AS RELATED TO INSECT MORTALITY (Bousfield, Young)

Attempts to relate spray deposit information with mortality have been tried in the past with varying success. Usually the sample design has not been compatible with the spray deposit cards and/or available funds were lacking to insure compatibility. With computerized systems now available, we have the opportunity to analyze more efficiently the spray deposit cards and relate them to mortality and residual insect populations.

The correlation between spray deposit data and insect mortality is dependent upon the insect population control resulting from the spray deposit. If the material tested was extremely effective with low dosages, probably no relationship would occur because total mortality could result. Note: When this occurs the project is a "success." Mortality was close to 1.0 resulting in a good project; however, regression analysis of the data would provide only limited additional information.

On the other hand, if a project had poor mortality results, or if natural mortality was unusually high, masking the effectiveness of the treatment, correlations would be low. Again regression analysis would not provide much additional information on the effectiveness of the material.

The sampling procedures used to determine insect mortality involves destructive sampling; i.e. the insects used to determine the pre-spray population levels are taken from a branch cut from the tree; the same insects cannot then be used to determine mortality after spraying. In order to reduce the variation in mortality, data is aggregated at the cluster or tree level. The procedure is outlined as follows:

1. Tree level data: for each tree, an average ($\bar{X}$) (spray deposit) and $\bar{Y}$ (mortality) values are determined from the number of branches and cards sampled.
2. Cluster level data: for each cluster in the spray block an $\bar{X}$ and $\bar{Y}$ values are determined from all branches and cards.

The next section outlines specific procedures for analyzing spray assessment data.

### A. Objective

1. Evaluate coverage in open areas.
    a. Cards are placed in open areas within the spray block; 3 or 4 open areas; 50 to 100 cards for the entire block.

b. Determine mean and standard error for $mg/m^2$, gal/acre $drops/cm^2$, vmd.

c. Compare these results with what was expected or specified.

2. Evaluate coverage from cards placed under trees.

   a. Four cards are placed under the drip line for each sample tree in the survey.

   b. Compute a nested analysis of variance for each variable measured to test the hypotheses that each spray block got the same rate; blocks, cluster within block, trees within cluster, location within tree.

3. Evaluate relation of mortality to spray deposit.

   a. For each spray deposit variable, $mg/m^2$, vmd, $drops/cm^2$, compute an average value for each cluster (or tree, depending on the original design).

   b. Compute an average value of mortality expressed as $\left(1-\frac{\text{post spray}}{\text{pre spray}}\right)$ uncorrected for natural mortality for each cluster (or tree).

   c. Plot the cluster averages, dependent variable being mortality and independent variable being mg/m's, vmd, $drops/cm^2$. One plot for each independent variable.

   d. The data can be plotted at the spray block level and for all blocks using the same treatment.

   e. Using the raw data plots, subjectively determine what type of regression model best represents the data, i.e. simple linear, quadratic, or some form of curvilinear fit.

   f. Transformations might be appropriate at this time; examples of transformations are:

      (1) dependent variable - mortality, $\arcsin\sqrt{\text{mortality}}$ expressed in angles,

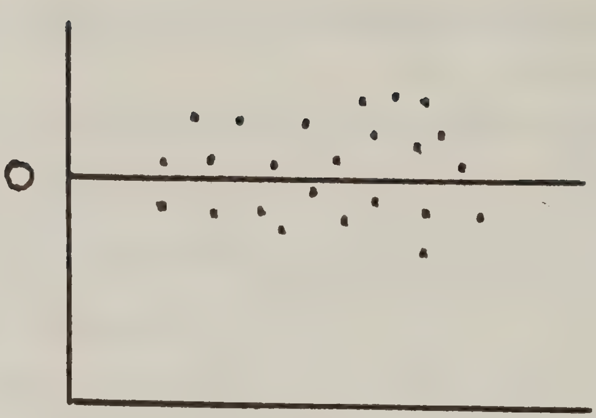
      (2) independent variable - $mg/m^2$, drops/cm log (base 10)

   g. Compute regressions based on appropriate model selected.

      (1) A plot of residuals $(Y-\hat{Y}$ plotted against the dependent variable Y is helpful in evaluating the goodness of fit for the selected regression model. If the regression model is properly specified, the plot will be random; i.e.

random error term

$e=(Y-\hat{Y})$

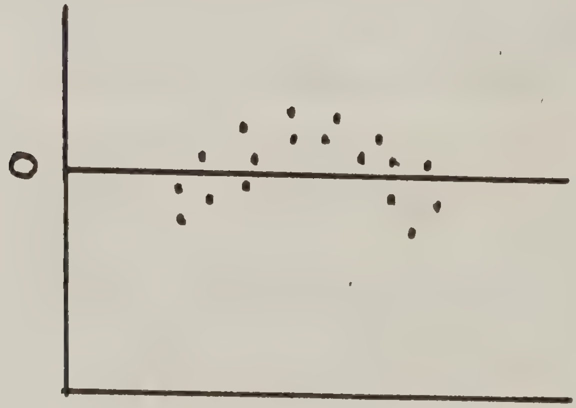


Y

There are no distinct patterns in the residuals.

If the model is not properly identified, the plot can look like the following:

$Y-\hat{Y}$



Y

Indicating that a more appropriate model would be a quadratic

$Y=b_o+b_1X+b_2X^2$

4. Evaluate the relationship between residual population and spray deposit. The same general type of analysis as shown in 3 can be done by using the residual population (post spray counts) as the dependent variable. Both mortality and residual population counts are of value in the analysis of field experiments, pilot projects and control operations.

RECOMMENDATIONS:

1. Define all variables used in the analysis and reporting:

   a. Timing (i.e. prespray, 7 days postspray, etc.)

   b. Aggregation of data, tree level (i.e. 4 branches per tree) or cluster level,

   c. Transformations used (be specific),

   d. Proper labeling of all charts and graphs.

2. Data analysis must be consistent with survey objectives and sample design; i.e. spray deposit data from one cluster (tree) cannot be related to mortality from another cluster (tree).

3. Plotting of raw survey data is suggested to determine what form the regression model takes.

4. Technical assistance is available from MAG to assist in the development of the analysis plans and interpretation of results.

## IV. REPORTING OF DATA (Bousfield)

Reporting time tables need to be part of all work plans. It is imperative the progress reports (preliminary reports) be prepared in time for planning next year's programs - say 3 months after the end of data collection. The final report should be prepared no later than one year after project, and more detailed manuscripts can be developed on an individual basis 1-3 years after the project.

RECOMMENDATIONS:

1. Reporting plans should be integrated into the workplans for field experiments, pilot projects and control projects.

2. Progress reports should be prepared within 3 months following data collection highlighting pertinent results, i.e., $mg/m^2$, $drops/cm^2$, vmd, gal/acre, and dosage-mortality distribution.

3. Final project report should be prepared within one year after project initiation.

4. Published manuscripts should be prepared on an individual basis (1-3 years later).

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